



Blow-in-Place Alternatives for Underwater Unexploded Ordnance (UXO) - Neutralization by Explosively Generated Plasmas (EGP)

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Objective

- **Neutralize UXO with minimal environmental impact (no detonation)**
 - **IM Materials**
 - **NSWC IHEODTD funded**
 - **Naval 5 inch gun round (Comp A-3)**
 - **Environmental Security Technology Certification Program (ESTCP)**
 - **Underwater Remediation**

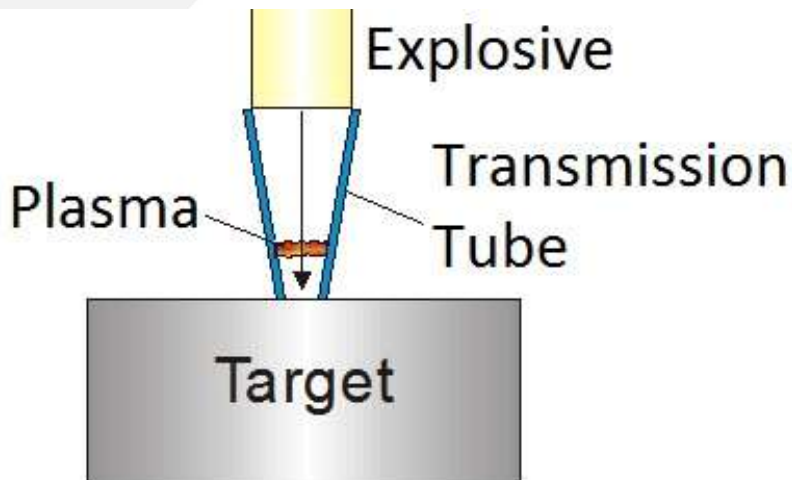


Knowledge Check

- What is the difference between Detonation and Deflagration?
- What is Dissociation of a gas?
 - For N_2 this occurs at 6,700 F
- What is Ionization of a gas?
 - For N_2 this occurs at 15,700 F

Background

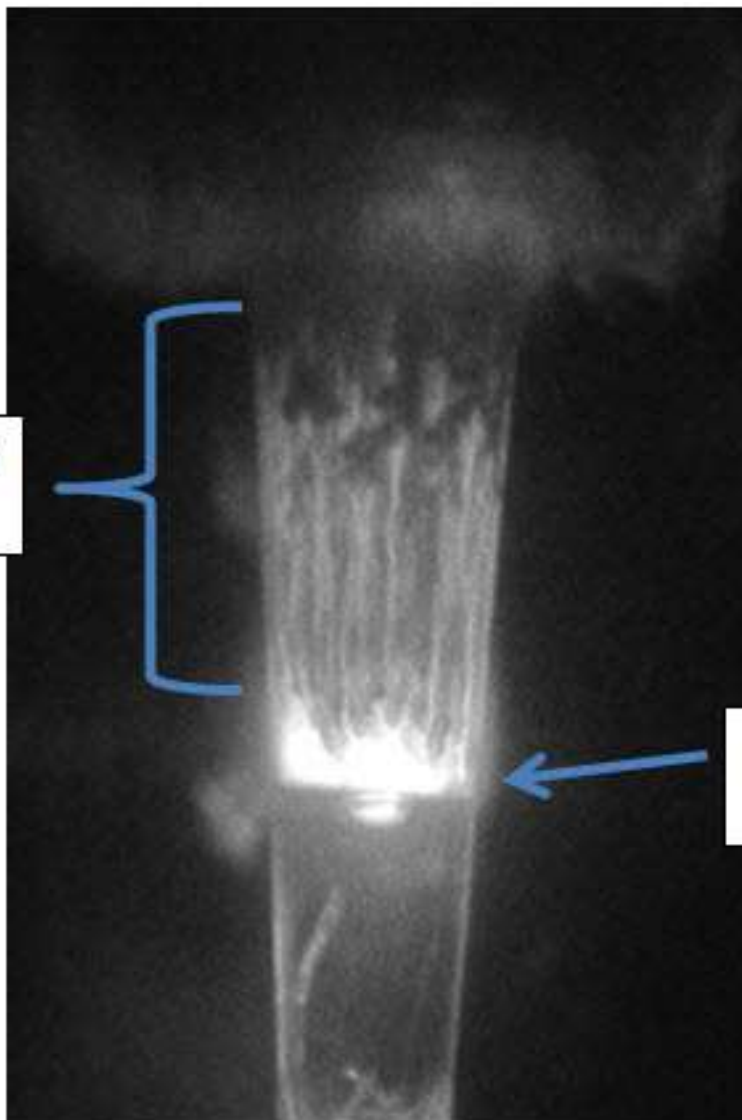
- **Explosively Generated Plasma (EGP)**
 - Ionized/dissociated product gases from an explosive charge
- **EGP Device – Conical transmission tube that directs the product gases & plasma to a target**



Picture of inexpensive EGP device with drop-in donor charge

Background

Explosive product gas
flow behind shock



NSWC IHEODTD and
LANL have worked
with EGP devices for
the last 25 years

Dissociation/Ionization
(plasma dynamics)

Photo Courtesy of
Blaine Asay and Nick
Glumac, University of
Illinois, unpublished.

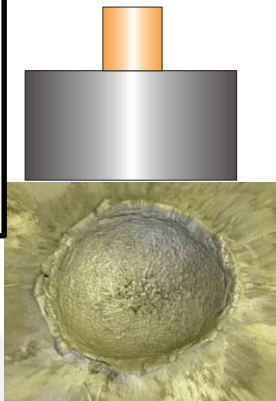
High speed photo of EGP

Penetration Capability

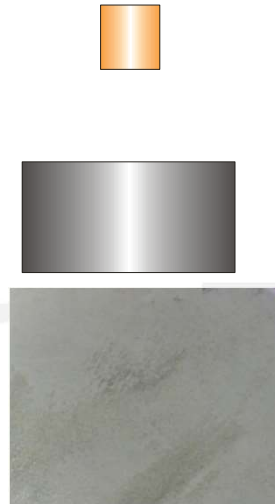
Highest
pressure
~30 GPa

Temp
~3,000 K

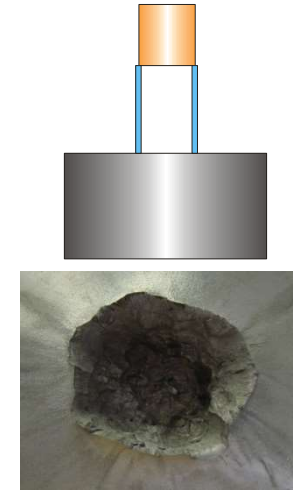
Pressure



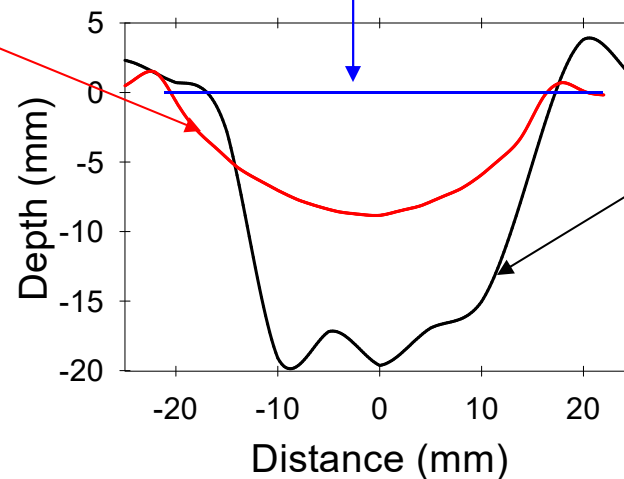
Blast



Plasma



Penetration is increased when the gas flow is confined in a transmission tube.



Highest Temp
~20,000 K

Pressure
~1 GPa

Penetration Performance

1"x1"
Charge
~20g

C4 Charge in
Plastic Cone



PBXN-5 Charge in
Plastic Cone



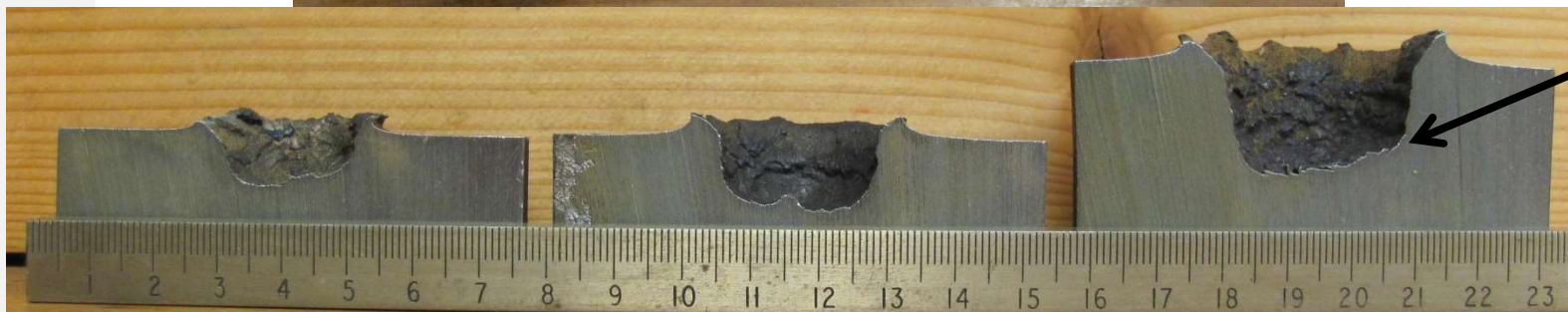
PBXN-5 Charge in
Steel Cone



3g PBXN-5
Booster



- Higher energy explosives increase penetration
- Increased interaction time increases penetration



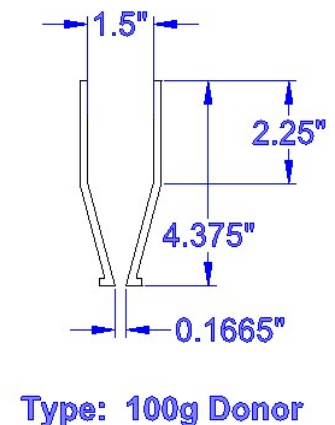
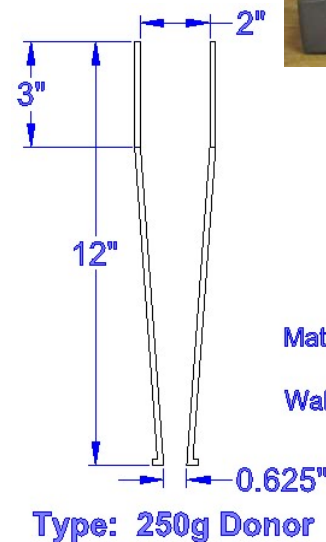
1/2"
depth

Penetration Performance Factors

Penetration is affected by:

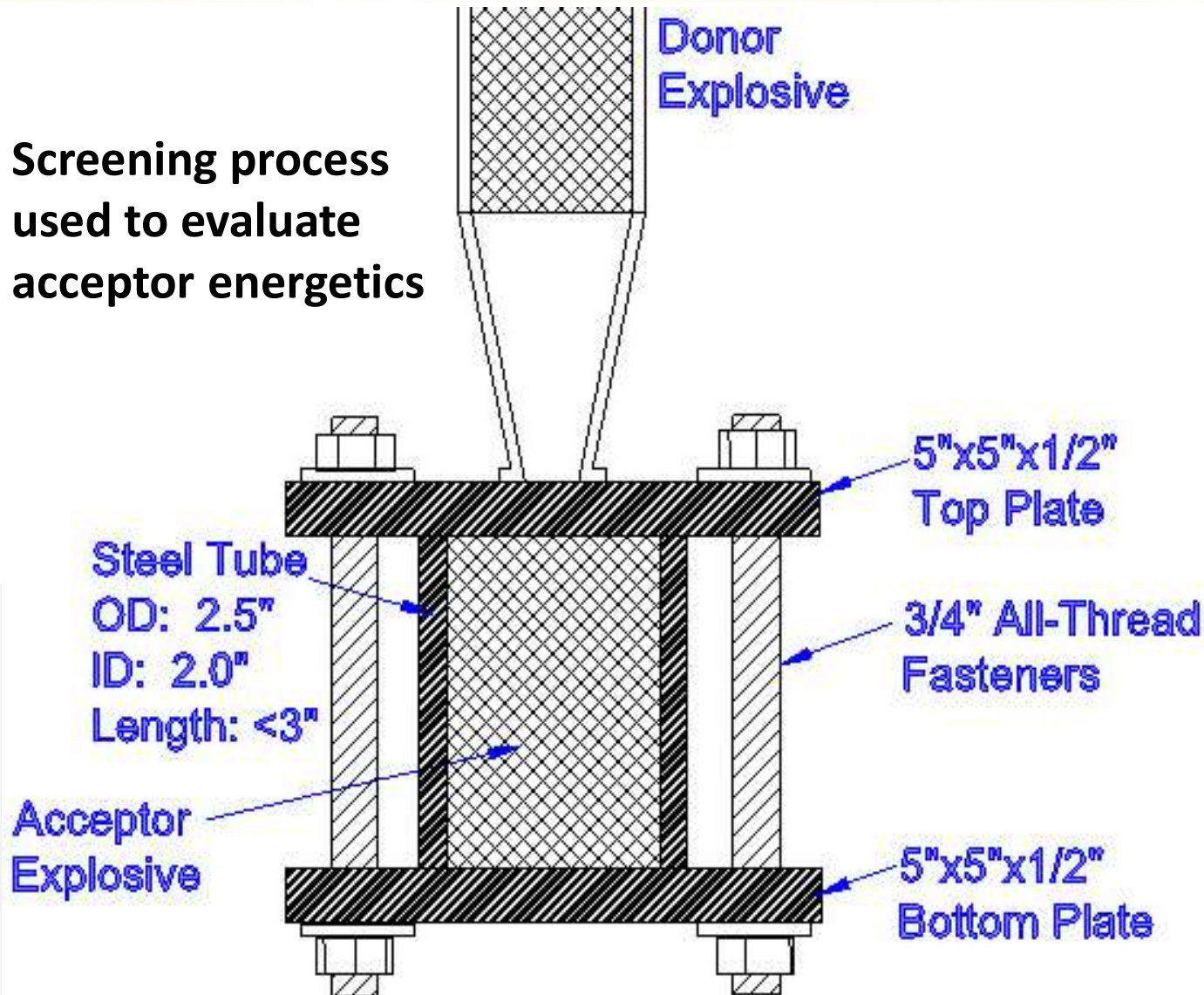
- Transmission tube geometry
- Donor explosive composition
- Confinement / Duration of event
 - Transmission tube thickness
 - Transmission tube material
- Donor explosive size
 - Systems are scalable

**2 systems that can
penetrate ½" of steel**



Acceptor Material Testing (UX0)

Screening process
used to evaluate
acceptor energetics



MIDN Gabriel Gosney

Acceptor Material Testing

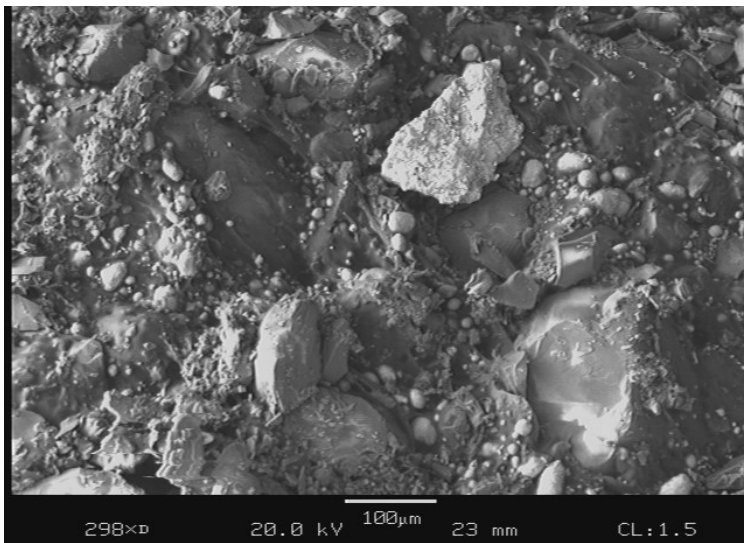
Explosive Composition	Density (g/cc)	HMX (%)	RDX (%)	NTO (%)	DNAN (%)	NQ (%)	AP (%)	AL (%)	Wax (%)	Binder (%)	Critical Diameter (in)	Reaction (Type)
PBXN-109	1.656	---	64	---	---	---	---	20	---	16	0.51	Burn
PBXN-113	1.67	45	---	---	---	---	---	35	---	20	< 0.375	Burn
AFX-757	1.72	---	25	---	---	---	30	33	---	12	1-1.5	Burn
IH-141	1.77	17	---	22	---	---	34	15	---	12	4.5-5	Burn
IMX-101	1.63	---	---	19.7	43.5	36.8	---	---	---	---	2.52-2.68	Partial Burn
Comp A-3	1.63	---	91	---	---	---	---	---	9	---		Burn*

- Materials with AP and Al stay burning once ignited
- Materials with no wax are easier to ignite

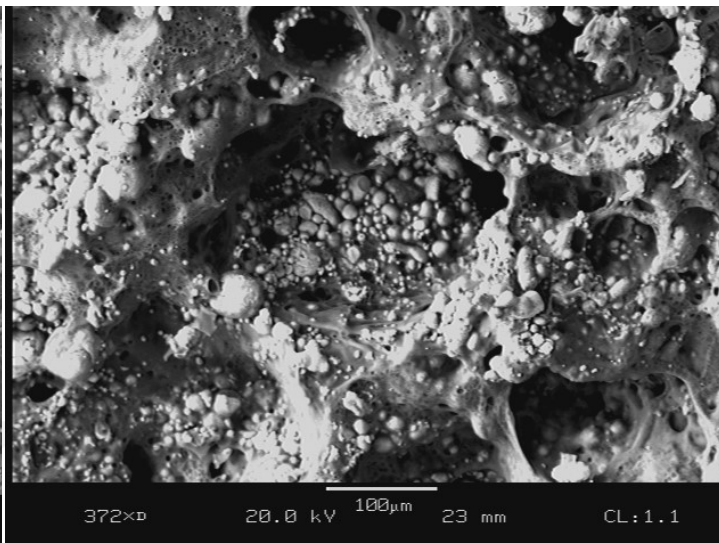
PBXN-109 Testing



PBXN-109 Rendered Inert

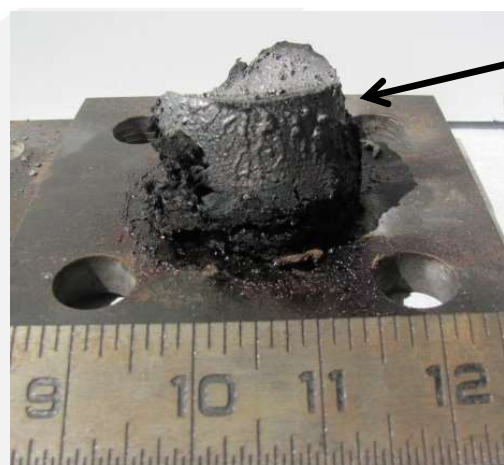


Pristine Material



Burned Material

**SEM images
of PBXN-109**



**Carbon and
Al₂O₃**

**Burned Material
(No energetics)**

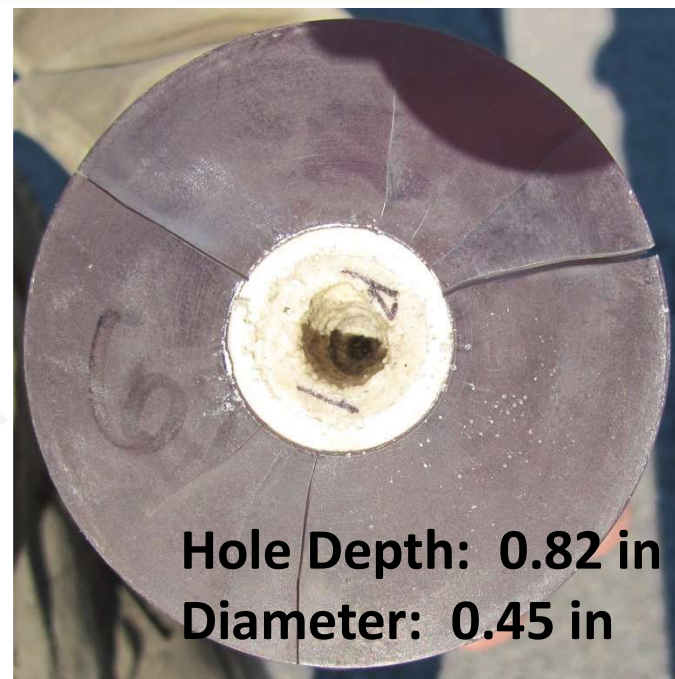
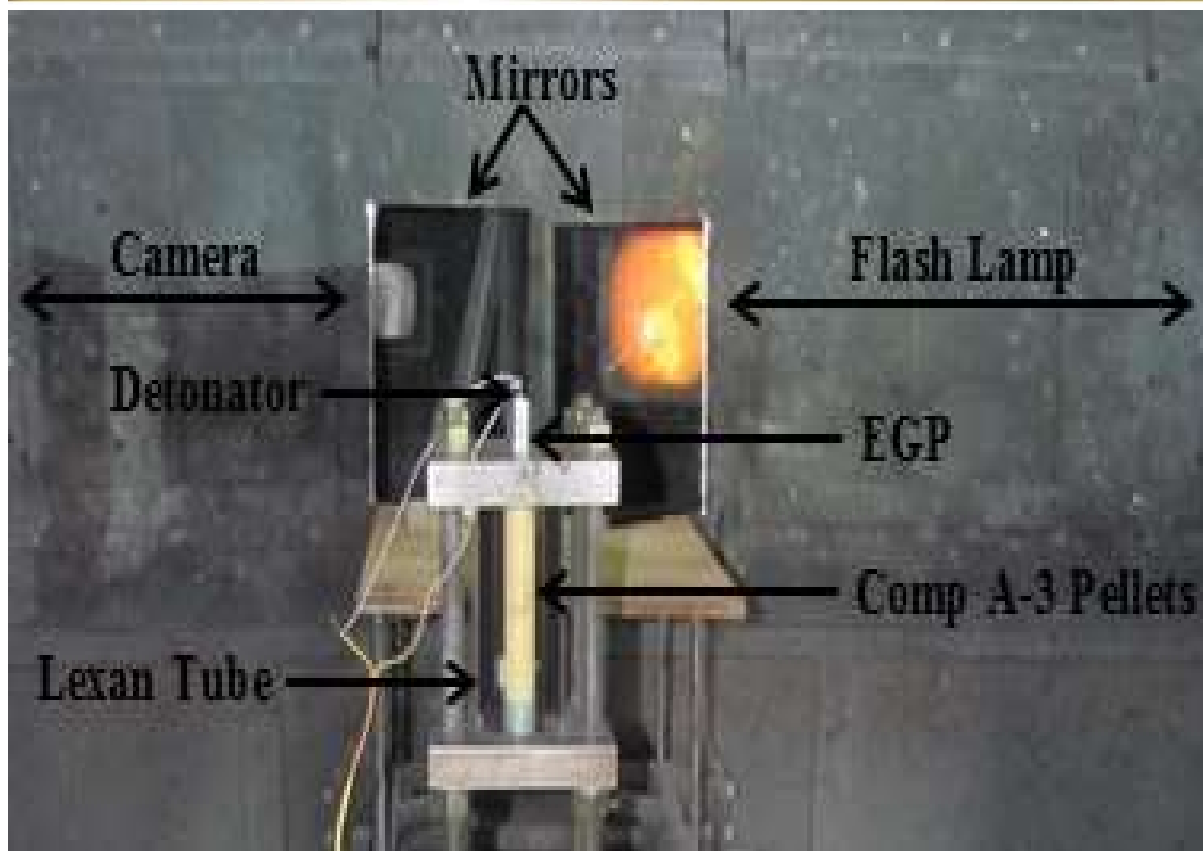
- No impact sensitivity (drop hammer)
- X-Ray Diffractivity (XRD) shows no RDX presence
- Handheld Raman and IR devices do not detect RDX/HMX

IMX-101 Filled 155mm Rounds



- **Single and Multiple EGP configurations were used to try to initiate IMX-101**
- **Unreacted material remained in each test**
- **The mass of the energetic was reduced by 80% when 4 EGP devices were used**

Comp A-3 – Burn Rate Tests



Hole Depth: 0.82 in
Diameter: 0.45 in

**EGP was in contact
with bare explosives.**

Comp A-3 can withstand high temperatures for short durations due to the heat capacitance and phase change of wax.

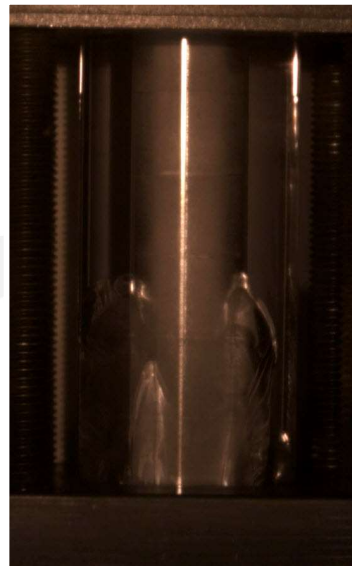
- **How should we approach this problem?**

Comp A-3 – Slow Burn Rate Test

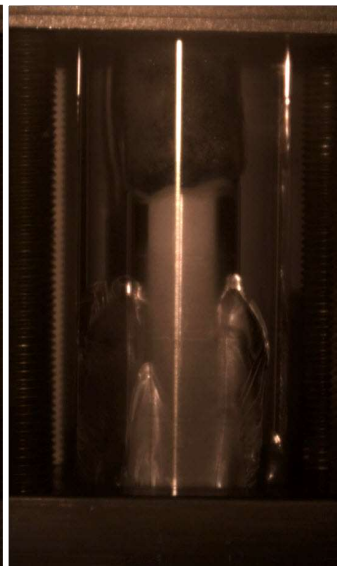
- A column of Comp A-3 was ignited using a small amount of Thermite
 - Answer the question – Will it burn?



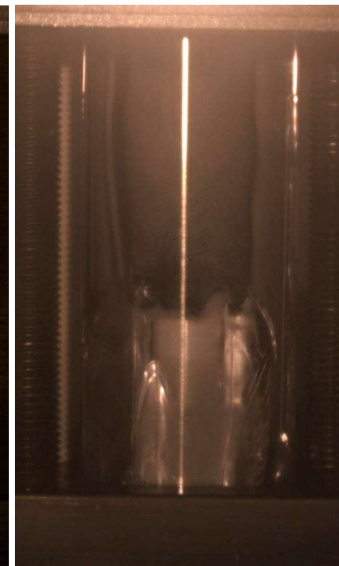
2 grams of Thermite
used to ignite Comp A-3



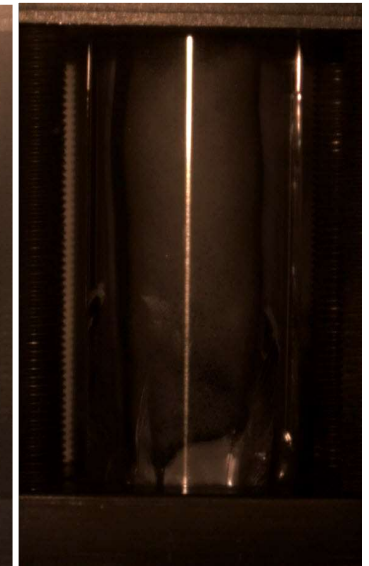
0 min



5 min



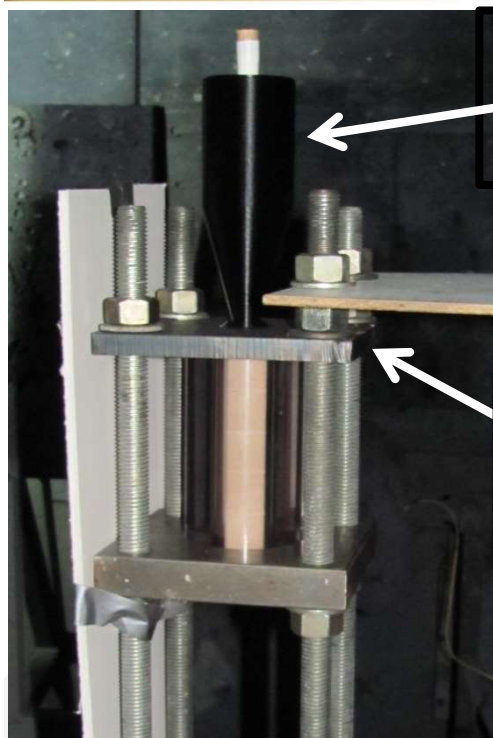
10 min



15 min

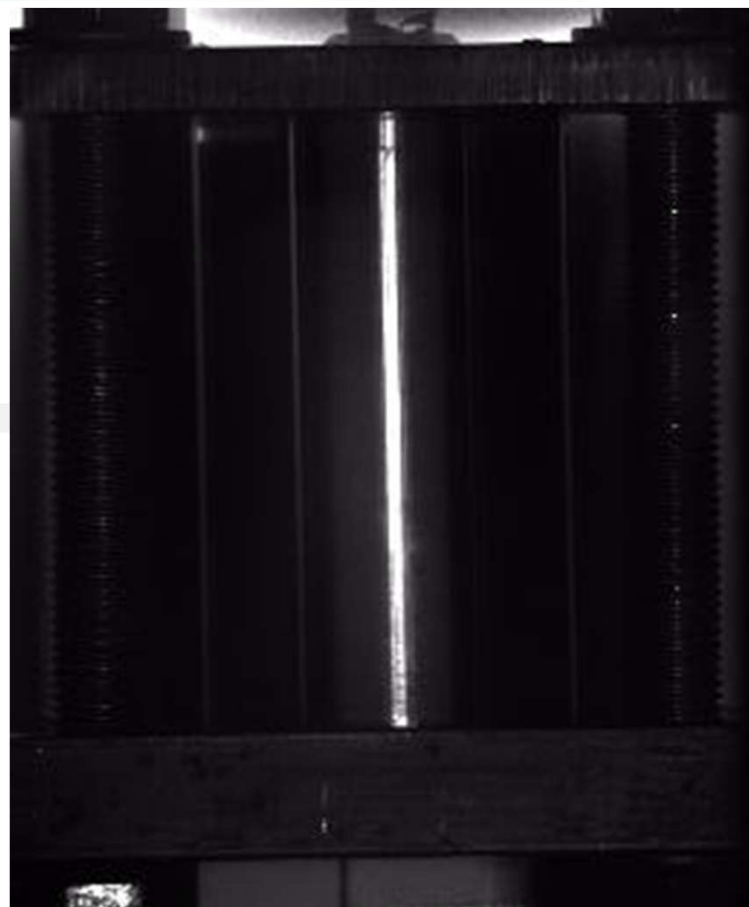
- Recorded burn rate: 0.37 inches/min
 - Too slow for underwater remediation

Comp A-3 – Fast Burn Rate Test



**EGP w/ 250 gram
donor charge**

**EGP fired through
1/2" plate**



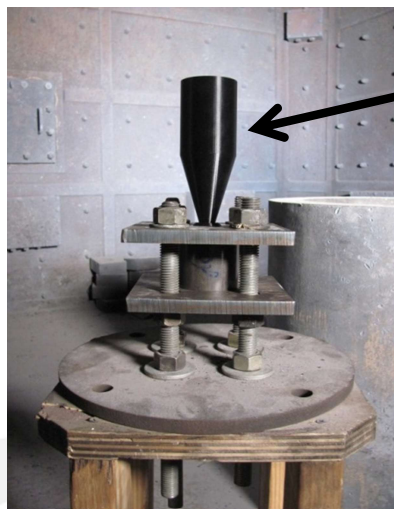
Recorded burn velocity: ~150 m/s

- **Much less than the detonation velocity ~8500 m/s**
- **Greatly reduced hazard**

Comp A-3 Acceptor Testing



Comp A-3

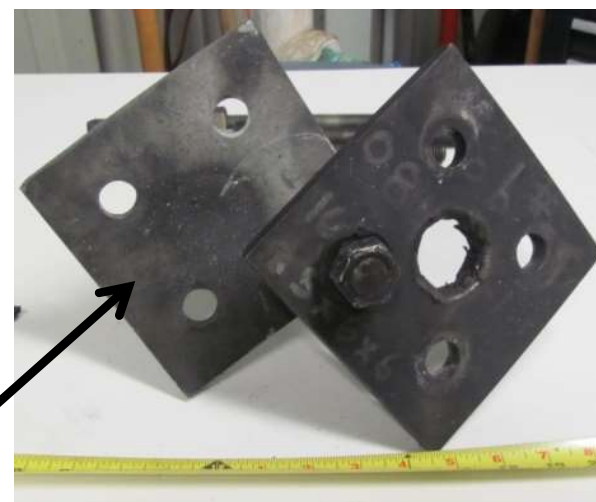


**EGP w/ 250 gram
donor charge**

**Large post-test fragments indicate
a low-order reaction. All Comp A-3
consumed.**



**Baseplate not
perforated**



Summary

- **EGP devices can be used to penetrate thick steel casings and burn explosive fills without detonation**
- **The device must be tailored to the UXO device (case thickness and explosive fill)**
- **Most modern IM materials are easier to defeat than older wax compositions**



Contacts and Questions

Points of Contact

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– samuel.emery@navy.mil

Questions ?



Supplemental Information

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